Infrared studies on the interplane charge dynamics of high-T_c superconductors: Interdependence between electronic correlations and superconductivity

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1 Introduction:

❖Both the iron-based and cuprate high-T_c superconductors have layered structure. Therefore their electronic properties in the *ab*- and *c*-directions are expected to be different.

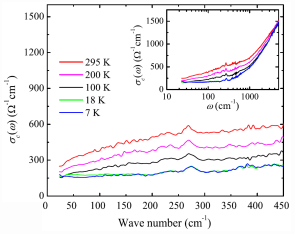
❖Infrared spectroscopy yields insightful and quantitative information on the electronic anisotropy of layered superconductors.

❖Magneto-optics instrument at UCSD allows to probe superconductivity-related changes in infrared spectra with high accuracy.

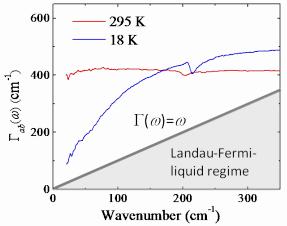
❖Here we present infrared spectroscopic studies of interplane *c*-axis charge dynamics of the iron-based and cuprate superconductors.

2 Incoherent interplane response of $FeTe_{0.55}Se_{0.45}$

c-axis optical conductivity



ab-plane scattering rate

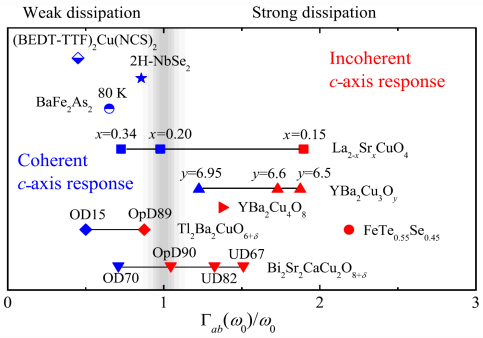


As temperature (*T*) decreases,
-the *c*-axis conductivity is depressed.
-spectral weight is transferred to higher energies.

The incoherent *c*-axis transport is related to the strong *ab*-plane scattering.

S. J. Moon *et al.*, Phys. Rev. Lett. **106**, 217001 (2011).

3 Interdependence between the *ab*-plane and *c*-axis responses

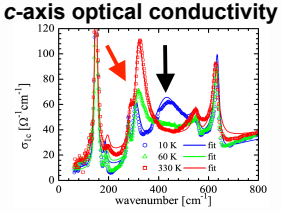


***ab* plane: $\Gamma_{ab}(\omega)<\omega$** **c axis: coherent**

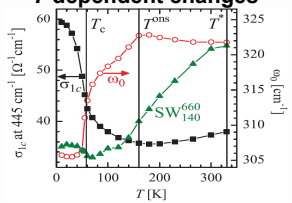
***ab* plane: $\Gamma_{ab}(\omega)>\omega$** ***c* axis: incoherent**

4 Interplane response of $YBa_2Cu_2O_{7-\delta}$ (T_c=58 K)

c-axis optical conductivity



T-dependent changes



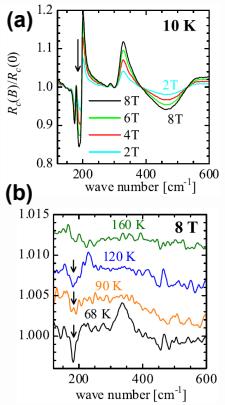
Pseudogap opening: decrease in *c*-axis conductivity

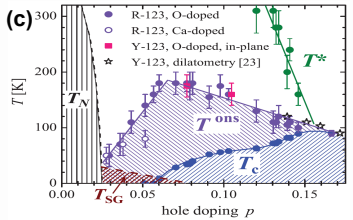
Superconductivity :
-enhancement of transverse plasma mode at 445 cm^{-1}
-softening of a phonon mode at 320cm^{-1}

The temperature dependence of *c*-axis conductivity shows that the superconductivity-induced changes start even at 160 K.

A. Dubroka *et al.*, Phys. Rev. Lett. **106**, 047006 (2011).

5 Precursor superconductivity at 180 K





(a) Field-induced change of reflectance spectra at $T<<T_c$
(b) Persistence of the field-induced change up to $T\approx160$ K
(c) Phase diagram obtained from magneto-optics measurements
→ Precursor superconductivity at $T\approx180$ K

6 Conclusions:

❖Infrared experiments reveal that the *c*-axis electronic response of $FeTe_{0.55}Se_{0.45}$ is incoherent.

❖In layered superconductors, the degree of *c*-axis coherence is related to the magnitude of *ab*-plane scattering rate.

❖Superconductivity with highest T_c tends to appear at the regime of $\Gamma_{ab}(\omega)\approx\omega$.

❖Magneto-optics measurements of $RBa_2Cu_3O_{7-\delta}$ demonstrate the existence of a precursor superconducting phase at 180 K.

❖Infrared spectroscopy is a powerful technique to search for global trends in the electronic properties of high-T_c superconductors.